TB2S:
Ladder integration

Eric Chabert on behalf CMS@IPHC

Person power

Staff:

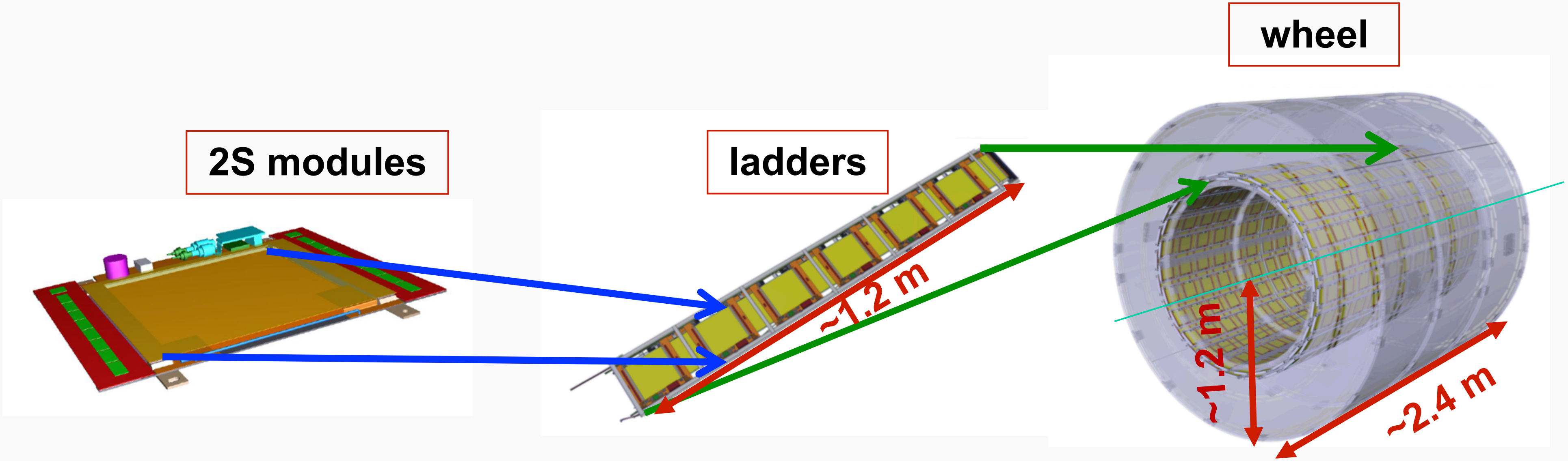
- 3 physicists: E. Chabert - J. Andrea – JM Brom
- 2 engineers: N Ollivier-Henry (tech. coord.) – S. Suzanne (quality)

Person power from TGIR:

pre-production: 2 “AI” (24 months)
→ The first one will be hired in 2019 for setting up the beam up and preparing the pre-production

production: 3 “AI” (24 months)

Ladder integration: Project in a nutshell

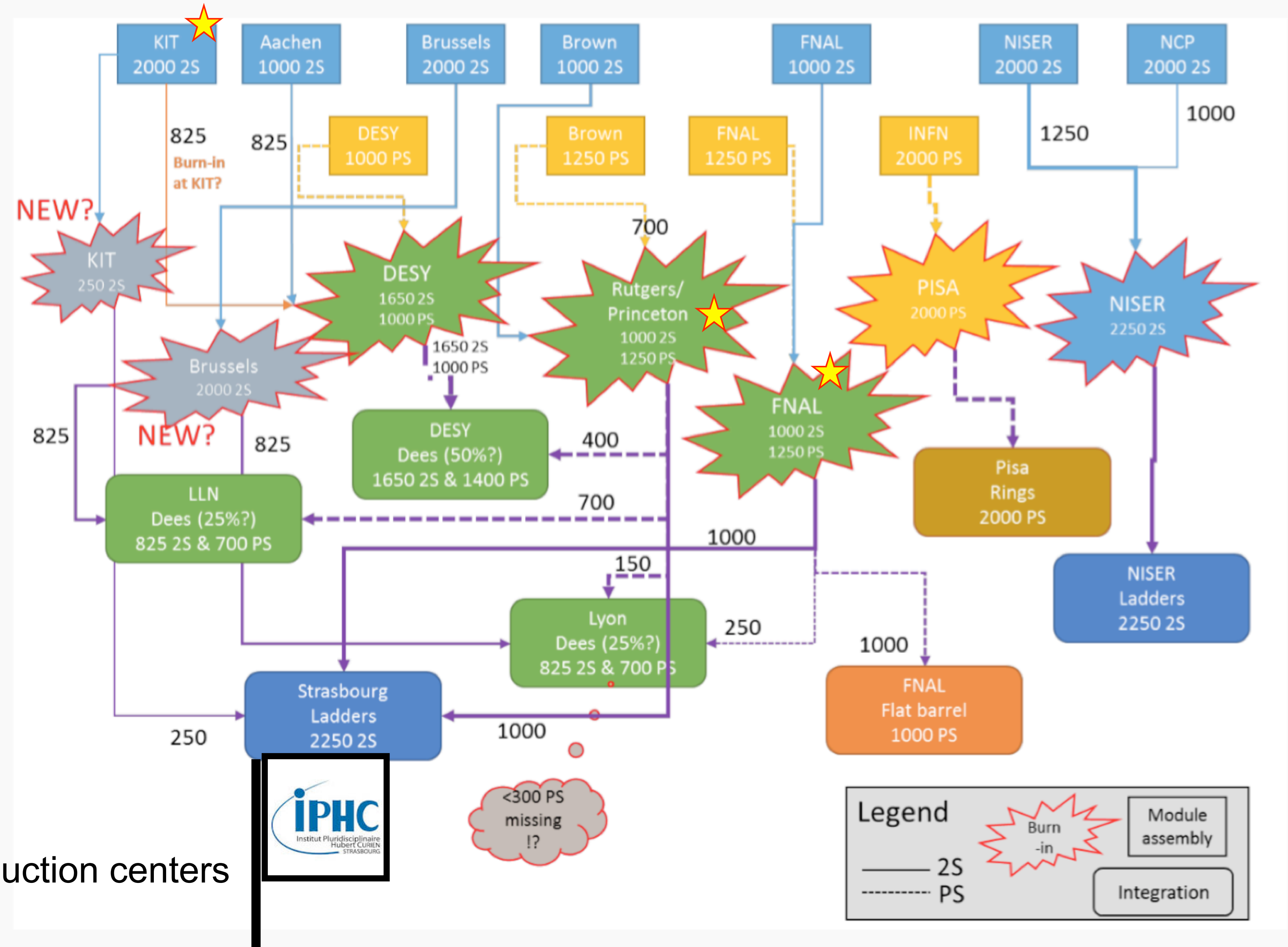


TB2S in few numbers:

- **4464 2S modules** (see next slide for production centers)
- **372 ladders** (12 modules per ladder, produced in Pakistan)

→ **Integration**: 50% by IPHC - 50% by Indian groups.

Ladder integration: Project in a nutshell



☆ Production centers

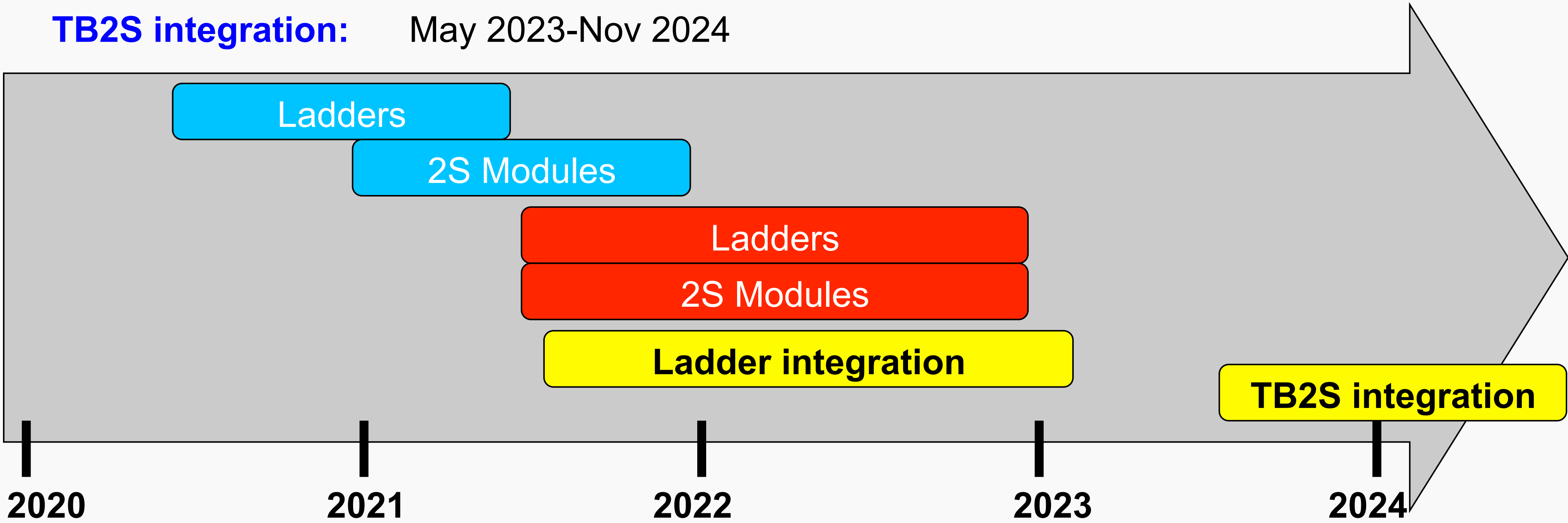
Timescale

Pre-production:
- Ladders: July 2020 - August 2021
- 2S Modules: Jan 2021 - August 2021

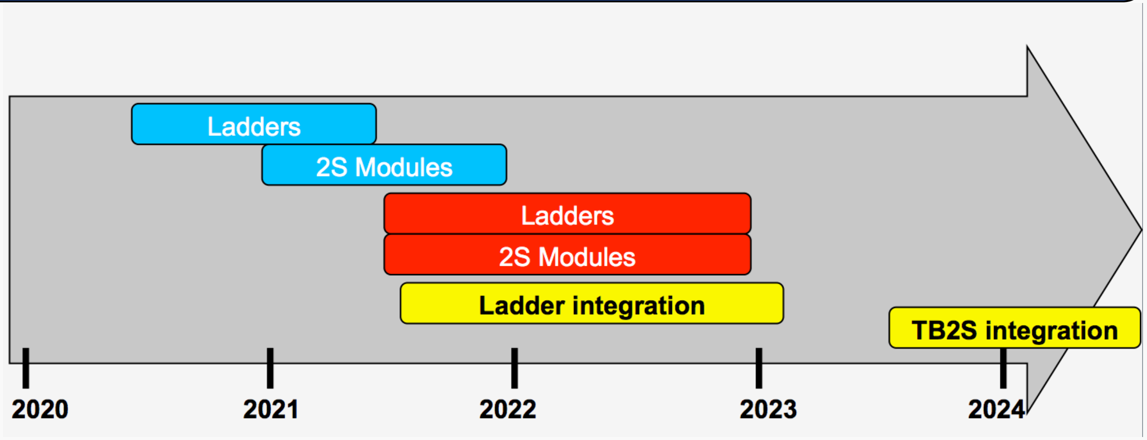
Production:
- Ladders: Sep 2021 - Dec 2023
- 2S Modules: Aug 2021 - Dec 2023

Ladder integration: Oct 2021 - Jan 2023

TB2S integration: May 2023-Nov 2024



Timescale



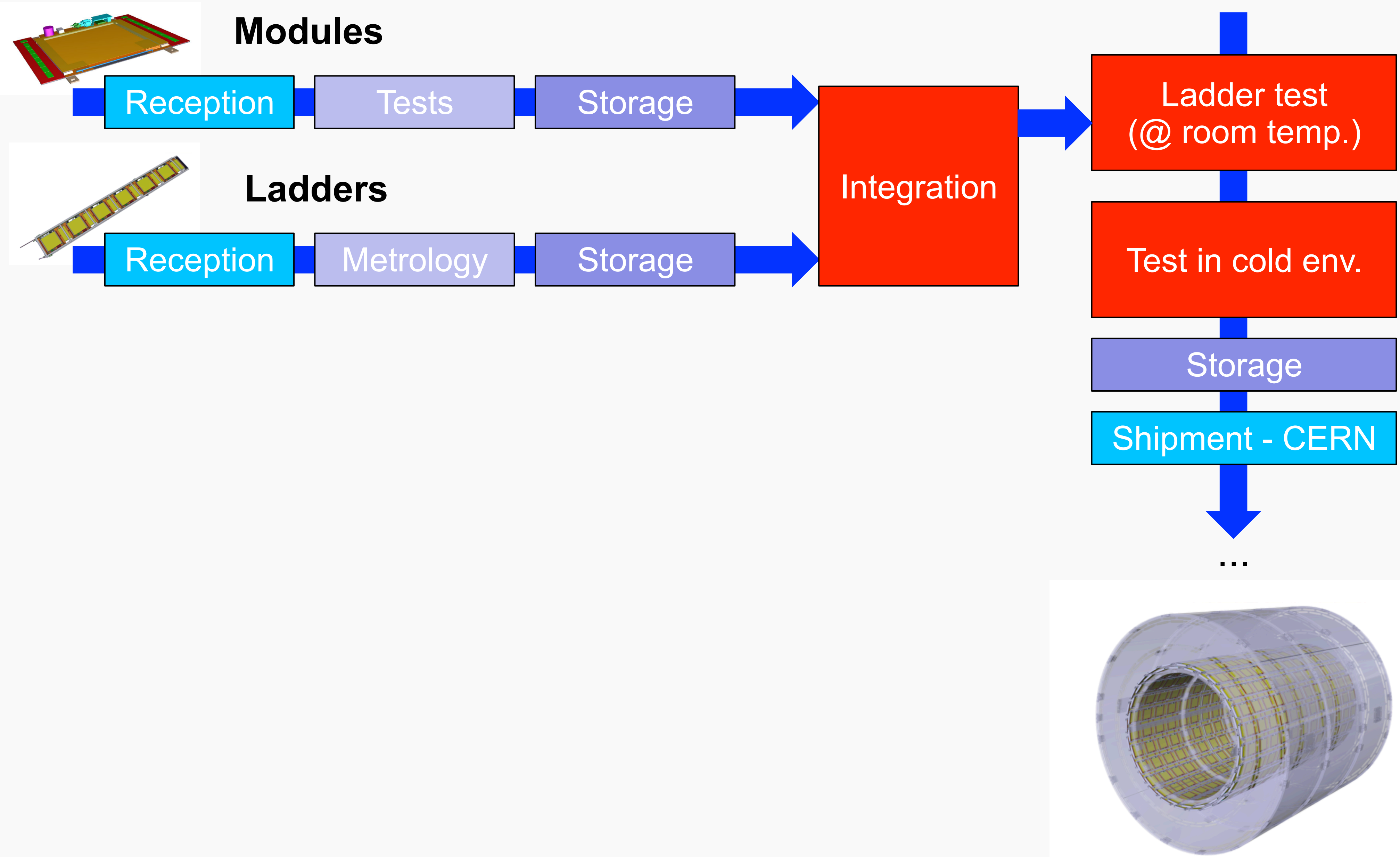
- **Preparation (2019-2021)**:
  - Prepare the integration facility
  - Setting up test benches (3 in total)
  - Organize and build the assembly lines (2 in total),
  - Preparation of shipments (build boxes, etc...)
  - Put in place quality procedures

- **Preproduction (2021)** :
  - “commission” everything with prototypes → adjust procedures & spatial organization *if needed*

- **Production (2022-2023)**.

- **Final integration done at TIF (2023-2024)**

Workflow *in progress*



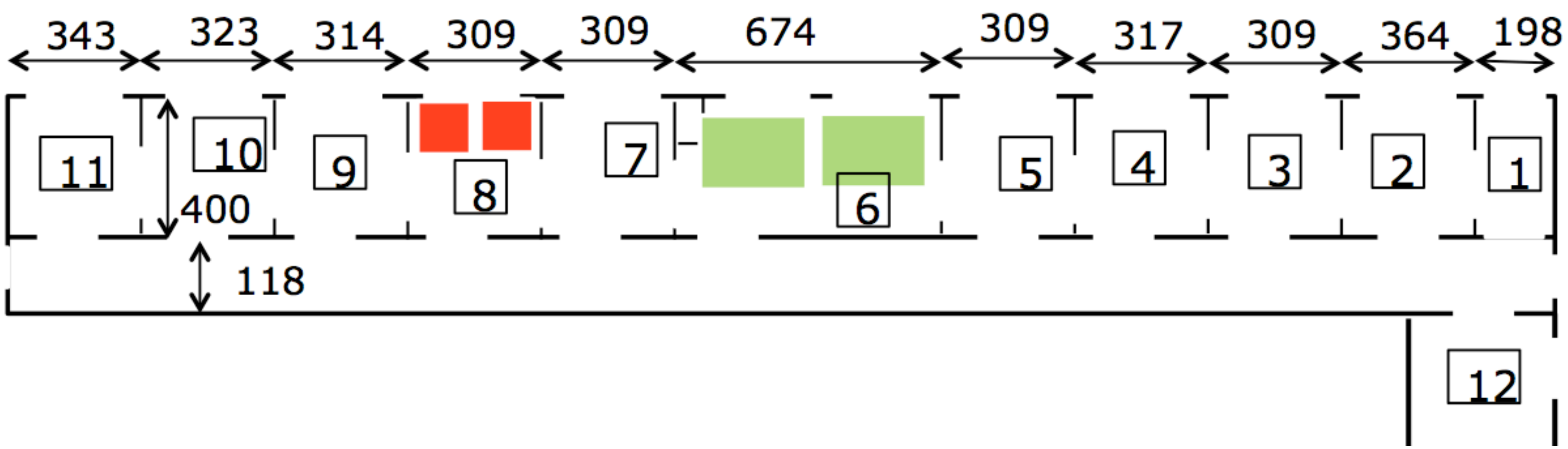
Integration @ IPHC: premises

Work expected for 2019:

- Renomation of electricity
- Increase the network capacity
- New badge access (both sides of the building)
- Install “emergency stop buttons”
- If needed: *installation of gas leakage alarm*

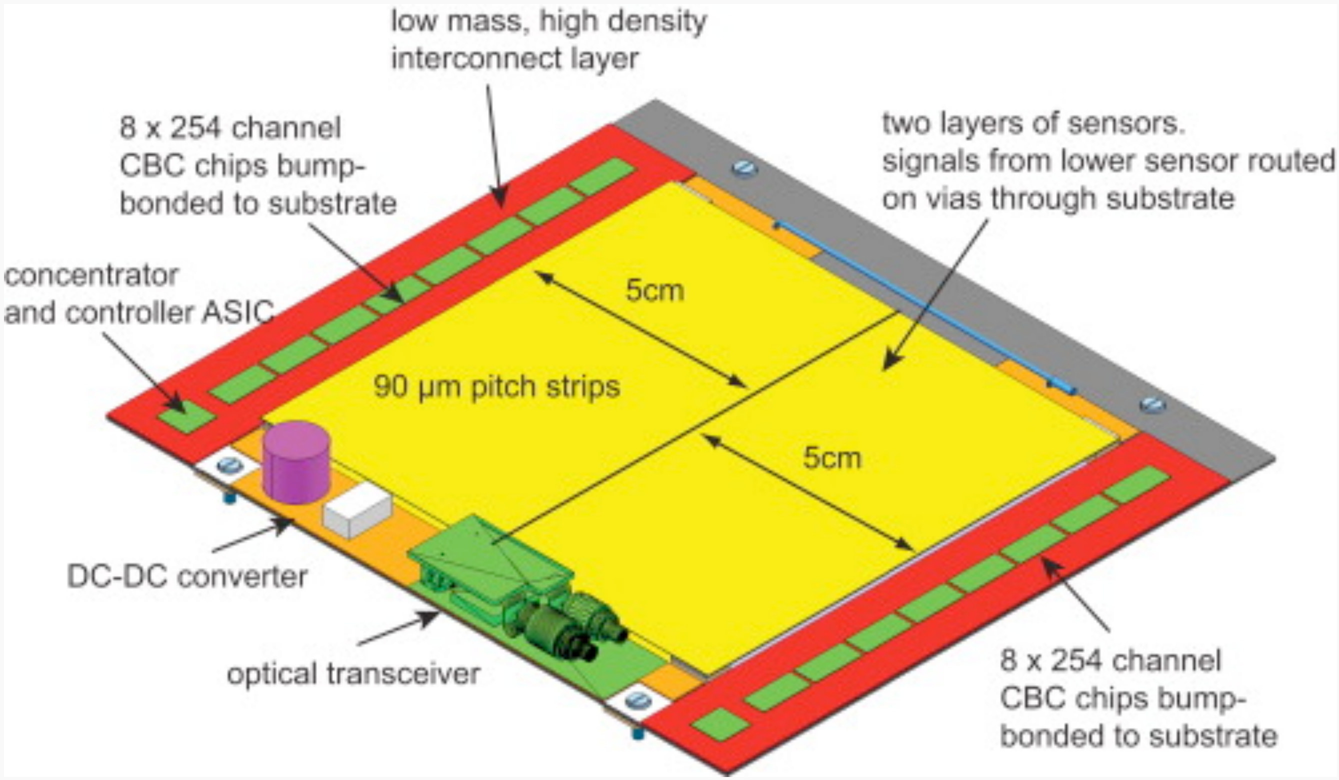
Integration @ IPHC: premises

Ongoing discussions to work on spatial organization
→ Will follow the workflow

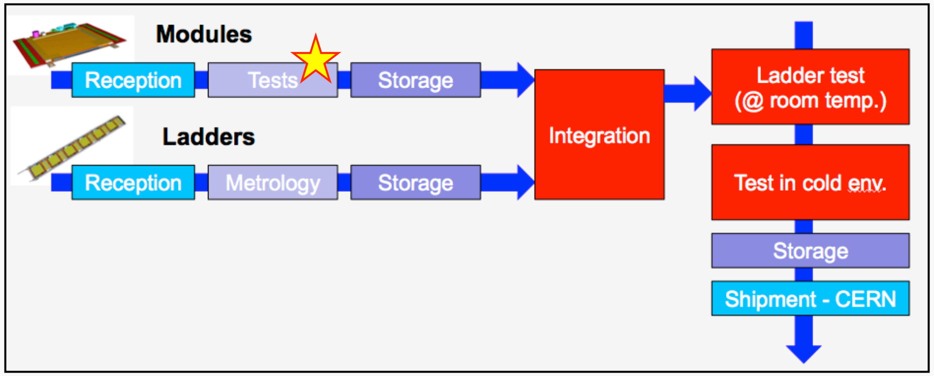


Room 1: Reception and documentation	Room 7: Storage of integrated ladders
Room 2: Reception & storage of modules	Room 8: test in cold environment
Room 3: Ladder metrology - Storage	Room 9: Unmounting & repair
Room 4: Module reception tests	Room 10: Preparation of shipment
Room 5: not yet assigned	Room 11: Relaxation area - Meeting room
Room 6: 2 integration lines - clean room - tests of ladders	Room 12: General storage

2S module


low mass, high density
interconnect layer
8 x 254 channel
CBC chips bump-
bonded to substrate
two layers of sensors.
signals from lower sensor routed
on vias through substrate
concentrator
and controller ASIC
5cm
90 µm pitch strips
5cm
DC-DC converter
optical transceiver
8 x 254 channel
CBC chips bump-
bonded to substrate

2S module: reception test



Connectivity & electronics

→ LV
→ calibrations

Visual inspection

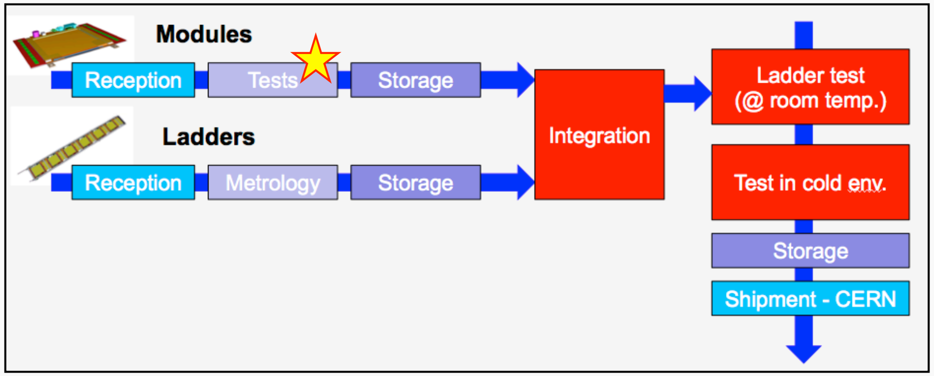
→ Check potential **damages** during transportation
→ In complement of shipment report (equipped boxes ?)
→ Built a list of elements to be investigated by the operators

Sensor

→ Compare threshold (*ie* noise)
→ Compare signal response (laser?)
→ Leakage current

Quality procedures need to be built far in advance and adjusted during the pre-production

2S module: reception test



Opened questions:

- Shipment: box/report
- Reference tests done in production center

→ Need to compare our tests with references

- DB: save results

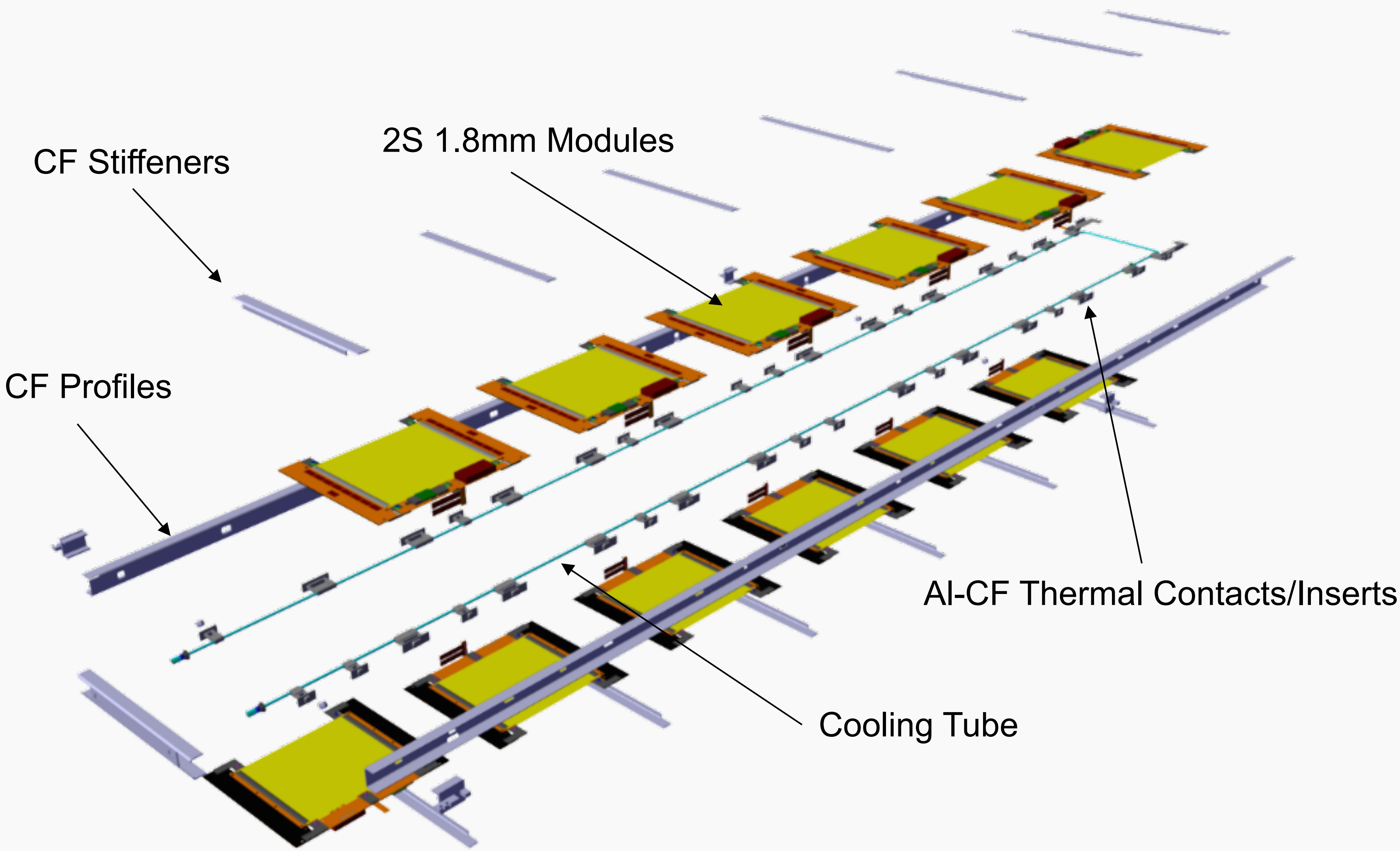
→ Follow DB development (structure/app)

- Quality:
  - Environment (*spatial organization*)
  - Methodology / Procedures
  - Operator training

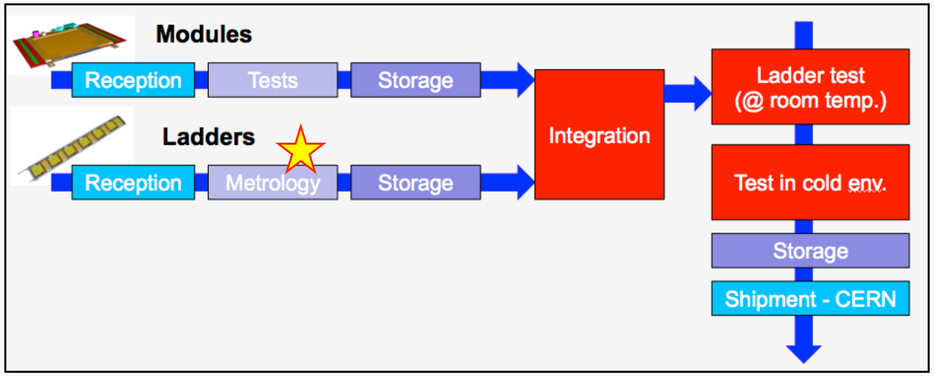
Setup *(test module individually)* **:**

- Visual inspection: binocular
- DAQ: Crate microTCA + FMC + FC7 + DAQ PC
- Power supply: LV & HV (+ NIM crate)
- Mechanical structure
- Environment (@room): no cooling/dry air …
- Signal: laser ?

Ladder


CF Stiffeners
2S 1.8mm Modules
CF Profiles
Al-CF Thermal Contacts/Inserts
Cooling Tube

Ladder : metrology



Recent activities:

- The mechanical group performed a “technological survey” (level arm, “MMT”, photogrammetry ⋯)
- Companies have been contacted.
- Company ***Hexagon*** came in our lab (presentation/measurements/discussions)

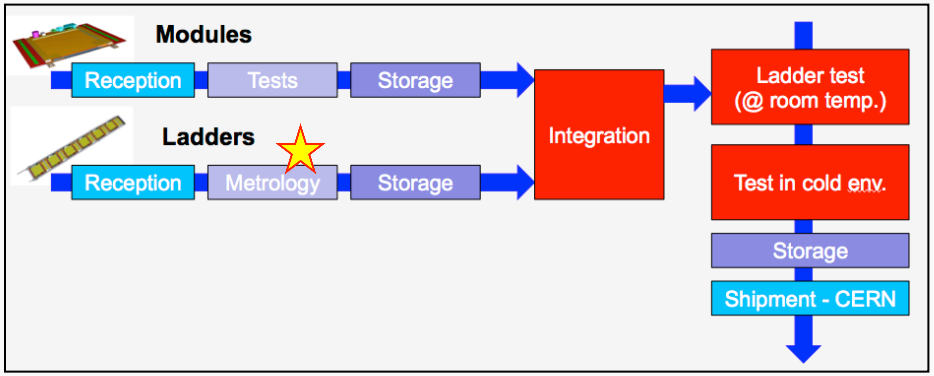
Current rough targeted resolutions:

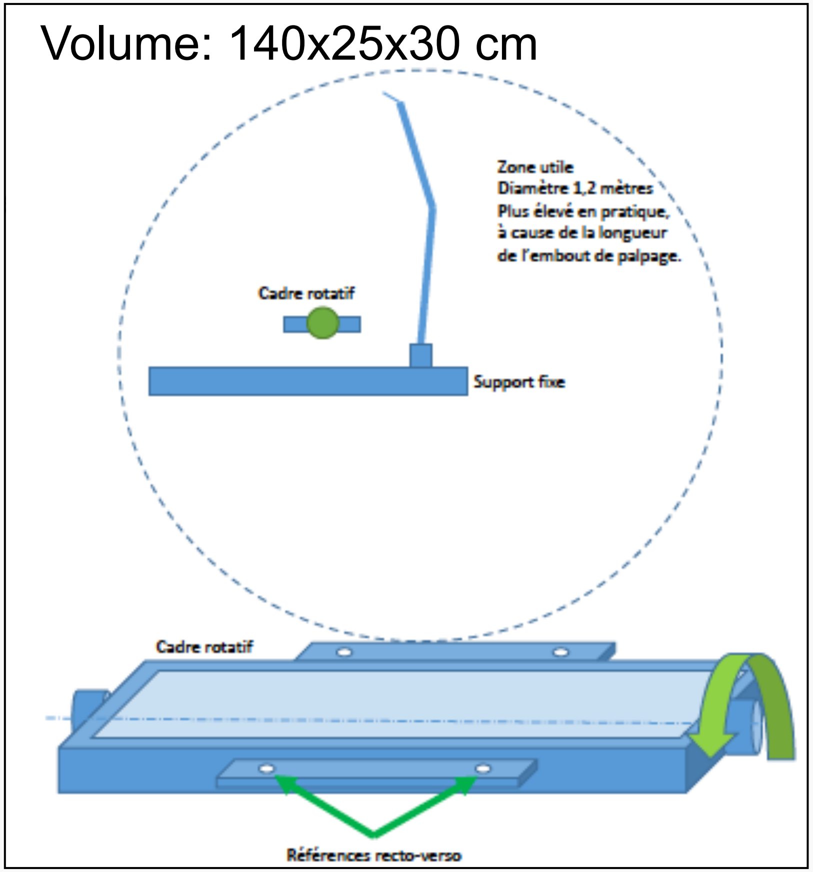
- ~ 50 µm for the planarity
- ~ 20 µm for insert position

Outcomes:

→ We’ve identified a **level arm** (HEXAGON/ROMER) that would suits our needs
→ Achieved **resolution** below the targeted ones: **6 – 18 µm**
→ **Software** (PDCMIS): programming & automatized report production

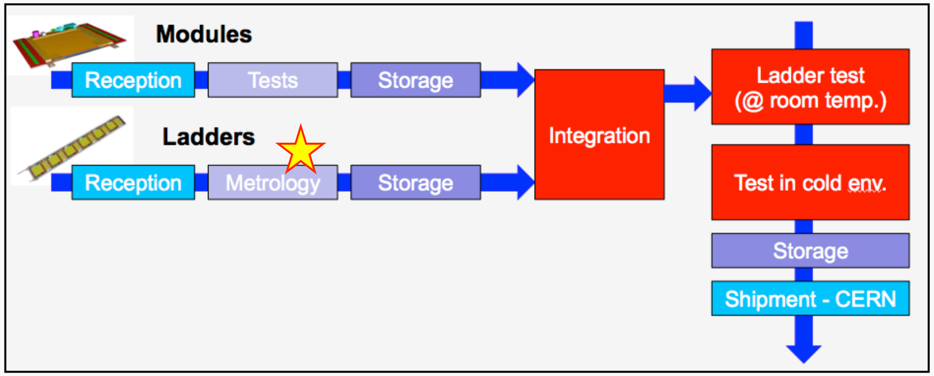
Ladder : metrology





Demonstration: sucessful test performed by the HEXAGON @ IPHC

Ladder : metrology



Setup:
- Need to prepare a equipped table under which the measuring arm will be fixed
- Need to develop/build a mechanical support to ladder: need to rotate the ladder

→ Reuse the one developed for TOB as an example
→ Mechanical constraints similar as the one in the real experiment

Future tasks:

Mechanics: structure + table
Quality:
- Environment
- Methodology
- Operator training

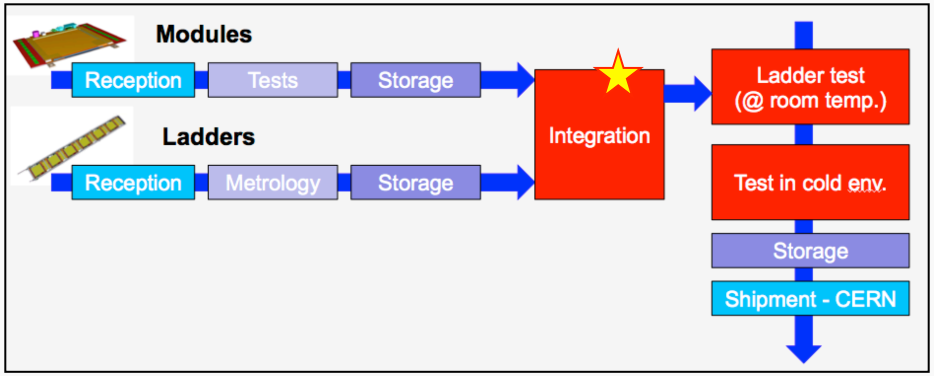
Software: automatization

Methodology:
- Evaluate the planarity of the bare (almost unconstrained) ladder
- Fix the ladder
- Evaluate the position of the connector for each modules (5 x 12 = 60)
- **Report**: built from a predefined list of measurements and a comparison with a CAO model

Opened point:
We've been asked to potentially perform also thermal tests
→ Require procedures, resources, …

Training:
- For the staff (by the company – 2 days)
- For the technicians (by staff)
- Check the repeatability and diminish human biases

Ladder : ladder integration



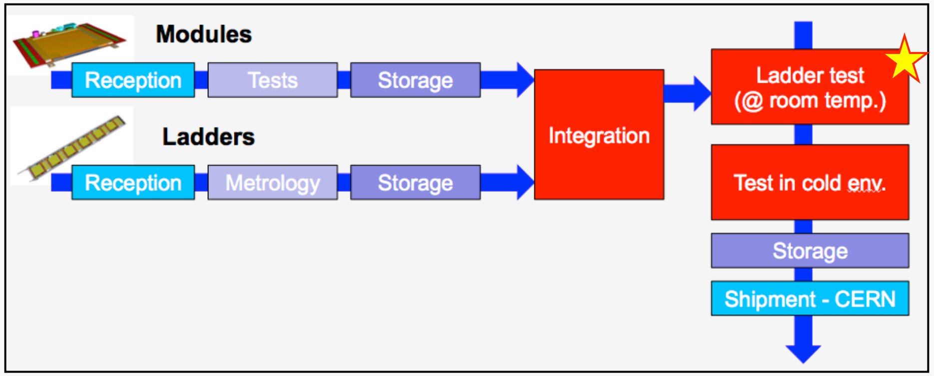
Infrastructure:

- 2 integration lines
- 2 laminar flux ceilings (reusing the ones from TEC construction)
- Option: having one disassembly line ?

Integration line:

- Need to build a table with mechanical support (similar to the one used for TOB)
- Need to rotate the ladder to integrate modules on both sides
- Built an environment (accessibility of tools, …) and procedure to be compliant with quality standards.

Ladder: tests post-integration



We need to perform tests on individual modules similarly to what is done during reception test. However, as we are growing in scale, additional tests are foreseen.

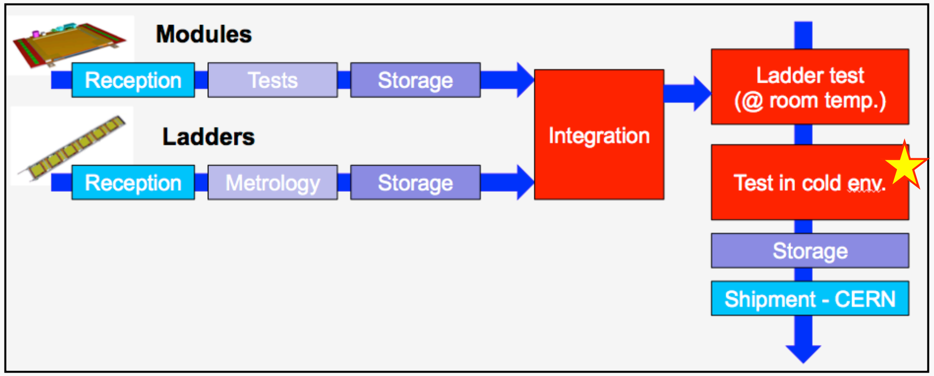
Key points to be controlled

- Grounding
- Cooling: leak test
- Thermal map (use a thermal camera)

Setup (12 modules)

- DAQ: Crate microTCA + FMC + 3 FC7 + DAQ PC
- Power supply: LV & HV (+ NIM crate)
- Mechanical structure
- Dry air
- CO_2 Cooling plant: MATRA

Ladder: test in cold environment



We plan to put several ladders (at least 3) simultaneously in the fridge as the cooling cycles take long time.

The DAQ setup is scaled to only measure a single ladder.
→ Need an automated patch panel

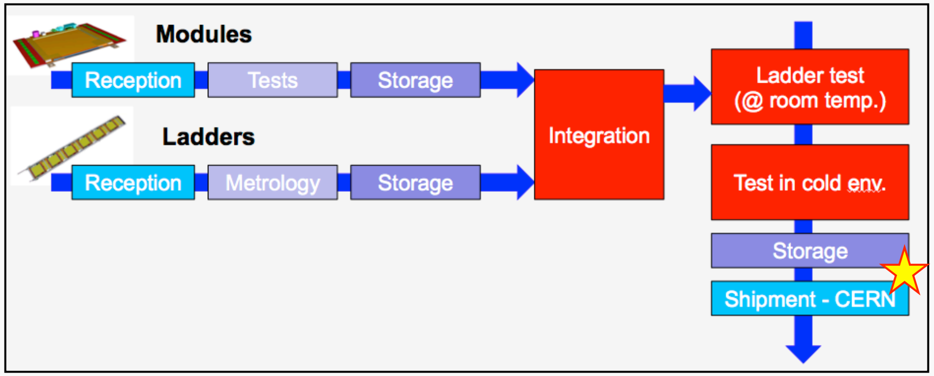
On top of the usual test, we foresee to perform I(V) curves at various temperature.

Setup (12 modules)

on top of the ladder test setup

- Equipped fridge (-25 ^{0}C)
- Dry air system
- Temperature/Humidity probes
- Patch panel

Shipment: storage

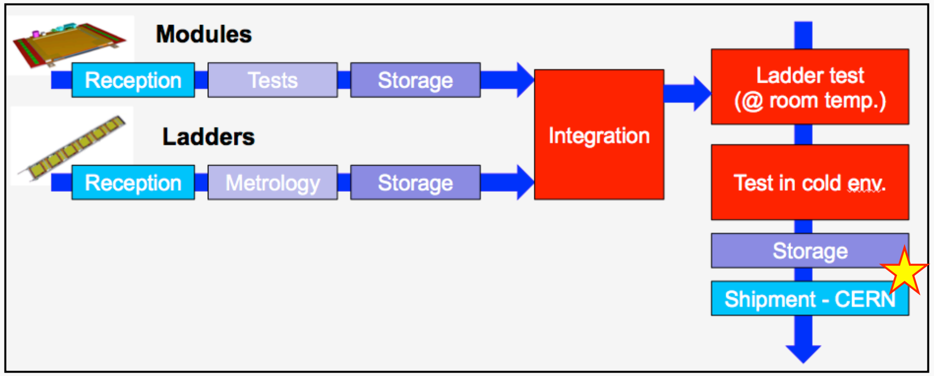


Storage are needed at several stages:

- **Reception of ladders**
  - No strong requirement
- **Reception of modules**
  - Reuse storage from TEC integration
- **Integrated ladders**
  - Ongoing discussion
  - Option:
    - dry air / azote
    - Ladders stored in individual boxes

Opened question:
what will be the buffer (time / #ladders) ?

Shipment: boxes



Need to develop boxes used for shipment of integrated ladders.

Constraints:

- Diminish damage risks
- Maintain low humidity environment
- Equip the box with sensors for traceability (accelerator, ⋯)

Finding a solution:

- Check for commercial solutions
- Design the box and contact companies for the production
- Interact with other CMS partners to find a collective and uniform solution

Integration of TB2S @ CERN

TB2S integration :

- installation of cables, fibres, cooling pipes etc…
- insertion of ladders into the TB2S wheel, cabling and testing,
- Exact list of actions still needs to be clarified.

Integration performed at CERN (TIFF).

(Benefit from experience from ladder integration and TB2S wheel assembly)

- Test of ladders at reception, can inherits from test bench developed at IPHC,
- Knowledge of TB2S mechanics will help,
- Development of common tools for ladders manipulation and storages.

In term of person-power, based on the experience from TOB, TB2S integration would require :

- 1 engineer and 1 physicist from IPHC, leading the activities,
- 2 technicians from IPHC,
- Team completed by ~2 technicians from India or CERN.

Pursue the work with the commissioning at P5 and participate to the data taking of first collisions.

Conclusions

- Ongoing design of the **workflow** (thanks for fruitful collective brainstorming)

- **Reuse past experiences and materials**
  - @IPHC: from petal integration
  - From CERN: TOB integration

- Many **opened questions**: need inputs from the collaboration

- As for all projects, "**anticipation**" is an import key work
  - Already found a solution for the ladder metrology
  - Renovation of the Building 30 will occur in the next months
  - Ongoing discussion for the quality procedure (visit of Olivetto – discussion with our quality engineer)

- Need to reinforce the collaboration with partners working on upstream and downstream tasks

Module heat transfert

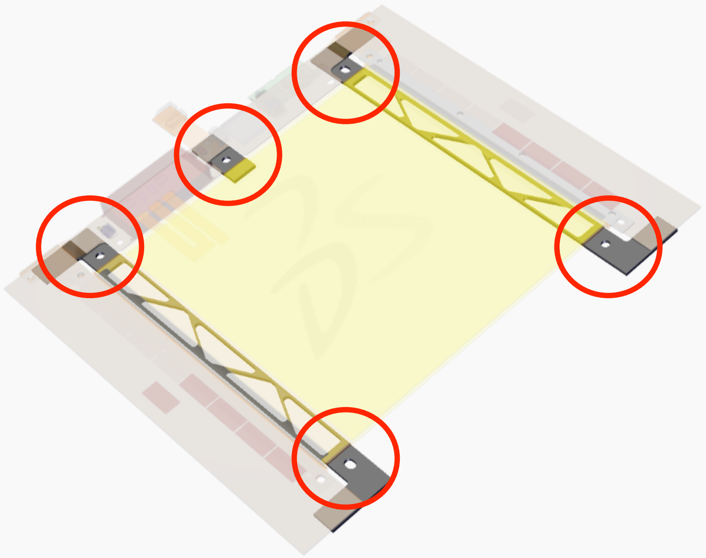
1 stump bridge and 2 long bridges

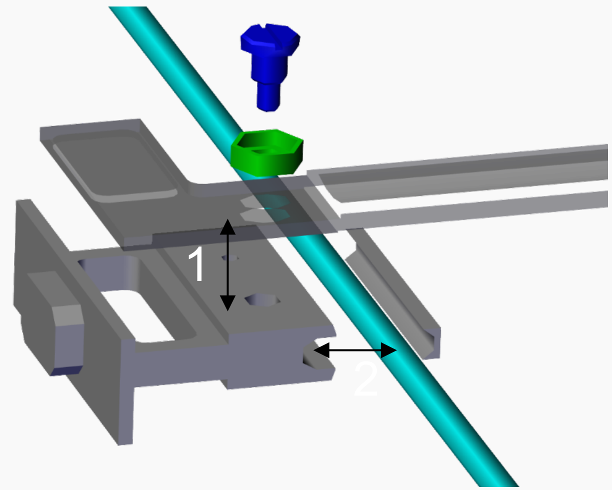
5 Cooling points per module

Aluminum – Carbon Fiber (Al-CF)

The thermal contact between the bridges and cooling inserts depend on the applied torque (1)

The pipe is Glued to the insert and pressed using the insert Cap (2)





Cooling of TB2S

12 2S Modules per ladder

2-Phase CO_2

3 ladders in a series

Stainless steel (SS) tubes (OD = 2.2 mm & ID = 2 mm)